Synchrotron Radiation Instrumentation
Collaborative Access Team

SRI CAT NEWSLETTER

Vol. 2, No. 2 October 1995

From the desk of the Executive Director:

The long awaited moment of first extraction of an APS undulator beam took place on August 9, 1995 at 10:05 pm in the 1-ID beamline. Under the auspices of Dean Heaffner, the Sector 1 ID Beamline Commissioning Team Leader, he and the other members of the Beamline Commissioning Team that assisted in this effort, in particular Mohan Ramanathan and Deming Shu, made the process a smooth one. Dean has also been a key participant, along with P. K. Job, in the important but sometimes not too glamorous activity of calculation/verification of the radiation shielding. Their initial radiation level measurements, a part of the 1-ID beamline commissioning program, were in good agreement with the calculations that had been performed. Thanks for the effort in an activity that is critical to all CATs.

Another important part of the Sector 1 ID beamline commissioning activities was the particle beam emittance measurements and spectral measurements of the undulator radiation, coordinated by Wenbing Yun. Preliminary commissioning of the Kohzu monochromator under low heat load conditions was led by Wah Keat Lee. Dean has summarized some of the details of the ID commissioning activities, in addition to BM line commissioning, in an article in this newsletter.

As pointed out in Dean's article, the initial diagnostics of the ID radiation on the 1-ID line indicate that the performance of the insertion devices exceeds the design goals. One such indication is the high number of harmonics that were visible in the measured spectrum. Kudos go to Efim Gluskin and the entire ID team for a job well done!

Construction activities are in full swing now with all the white-beam stations erected and work on several of the monochromatic stations underway. Equipment also seems to arriving on a regular basis nowadays. A 1.2-m-long side-cooled ("pink" beam) mirror for the Sector 2 BM line has arrived from Rockwell, and we are expecting the 0.88-m-long white beam mirror any day now. A closed-loop cryogenic system fabricated by Oxford Instruments has been delivered and is currently undergoing testing. And all the monochromators for Sector 2 (two double-crystal monochromators and two spherical-grating monochromators) are now on site. We expect the 1-BM monochromator, being designed and fabricated by Physical Sciences Laboratory, to be delivered before the end of the calendar year. For those of you attending the SRI CAT meeting on Tuesday, October 17, you can get more information on the details of these components from the SRI CAT members at that time.

Dennis Mills, Executive Director, SRI CAT

Contents

HEAR YE!! HEAR YE!! HEAR YE!!

It is with great pleasure that we confer this most distinguished honor to Linda Carlson of the APS Experimental Facilities Division for being selected as the WINNER of the SRI CAT Logo Contest!

Among the plethora of lesser distinctions she will receive, Linda, as the recipient of the Logo Contest Winner's Prize will also have bestowed upon her:

the very first
SRI CAT T-shirt,
emblazoned with the
new,
full-color,
SRI CAT logo
and
a special serenade by
Bonita Meyer!

Inelastic X-ray Scattering and the Metal-Insulator Transition in V_2O_3

Scattering experiments have provided much of the information available today about the microscopic behavior of an enormous variety of condensed matter systems. Simple but fascinating systems like solid and liquid helium, transition metals like Fe and Ni, semiconductors like Si and GaAs, and complex oxides like V_2O_3 and high-T_c superconductors, to name just a few, have been investigated by a variety of scattering probes. In particular, from inelastic scattering measurements we learn about the low-lying excitations. These excitations have a wide variety of properties, such as electronic charge and magnetic spin excitations (magnons) and excitations produced from nuclear motion (phonons). From their behavior, for example, their momentum or temperature dependence, we can learn about the nature of systems exhibiting these excitations, such as their color, thermal properties, magnetic properties, electrical properties, etc. The excitation energies of interest range from tens of electron volts (eV) for the collective charge oscillations of the plasmon down to tenths of milli-eV for many superconducting gaps. Because of the enormous variety of interesting excitations and because of the large range of momentum and energy scales of interest, various probes must be used. However, x-rays and neutrons have been, and will continue to be, the scattering probe of choice at atomic length scales because they interact weakly and couple to the important degrees of freedom of condensed matter systems. Moreover, advances in synchrotron sources of hard x-rays, such as at the NSLS and the APS, promise to open a new frontier in the use of x-rays to study electronic excitations in the milli-eV to eV range.

One very interesting current problem in condensed matter physics is the metal-insulator transition (MIT) in highly correlated systems. Transition metal oxides, such as the parent high-T_c materials, La_2CuO_4 and V_2O_3 , are examples of such systems. V_2O_3 is particularly interesting because the strong electronic correlations lead to a very rich phase diagram, including a strongly renormalized Fermi liquid at room temperature, characterized by a large linear specific heat (γ = 54 mJ/mol-K^2V), which can be transformed into an antiferromagnetic insulator by cooling or a paramagnetic insulator by doping with Cr.[1] V_2O_3 has long been considered to be a classic example of a Mott-Hubbard[2] system in which the insulating gap forms from the short-range Coulomb interactions between electrons. However, the usual single-band picture of the Mott-Hubbard model is a considerable oversimplification because of the many degrees of freedom associated with the atomic $V(3d^4 4s^1)$ and $O(1s^2 2p^4)$ orbitals near the Fermi surface of V_2O_3 . It is thus evident that the electronic excitation spectrum, and its changes through the MIT, should be highly interesting in this system. Because the Coulomb interactions that drive the transition occur on short length scales (d ~ V - V spacing ~ 3 Å), measurements at finite-Q are essential for a complete understanding of the MIT. The only suitable probe of the electronic excitation spectrum at finite-Q is inelastic x-ray scattering.

Our inelastic x-ray scattering measurements were carried out at the X21 beamline at the National Synchrotron Light Source.[3] The inelastic scattering spectrometer, which is shown in Fig. 1, was a triple-axis instrument consisting of two optical elements and the sample. The first element was a cylindrically bent Si(220) monochromator which focused 2 mrad of radiation in the horizontal plane onto the sample with an energy resolution of δE 0.8 eV at 8 keV. The spot size on the sample was 0.2 mm in the horizontal by 10 mm in the (unfocused) vertical. The sample was mounted inside of a Be can on the cold finger of a closed-cycle ^{4}He refrigerator. A spherically bent (R-1 m) Si(444) or Ge(444) analyzer was mounted one meter from the sample on the two-theta arm of a Franke-Heidrich two circle spectrometer. In this geometry, the analyzer produced a monochromatic image of the spot on the sample at a Ge solid state detector, also placed one meter from the analyzer. For E_{inc} = 8030 eV, the Si(444) analyzer gave a final energy resolution of δE 1 eV, a Bragg angle of 80 degrees (see Fig. 2). This resolution includes the bandpass of the monochromator, the intrinsic resolution of the bent analyzer (~120 meV)[4], and the finite spot size on the sample whose broadening is given by Braggs' Law to be $\delta E' = E_{inc}\,\delta\theta^* \cot(\theta_B)$ 0.3 eV, where $\delta\theta$ = 0.2 mm/1000 and θ_B is the analyzer Bragg angle. Inelastic scattering spectra were obtained by fixing the analyzer angle and scanning the incident energy. The momentum transfer, Q-2k_i sinθ, was varied from 0.5-5 $Å^{-1}$ by scanning the two-theta arm.

The ultimate energy resolution of

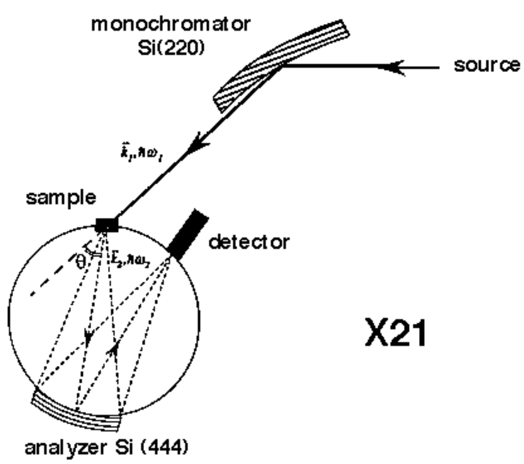

Figure 1. *Triple axis backscattering spectrometer for inelastic x-ray scattering at the National Synchrotron Light Source Beamline X21. The three axes consist of a monochromator, the sample and the analyzer.*

the backscattering spectrometer configuration described above is limited only by the intrinsic resolution of the monochromator/analyzer reflection (e.g., 40 meV for flat Si(444)). The flux that remains after the intrinsic resolution has been achieved depends on the brightness (photons/sec/mrad^2/mm^2/ 0.1% energy bandwidth) of the source. High brightness sources for inelastic scattering include the wiggler X21 beamline at the NSLS. The soon-to-be-available undulator sources at the APS, for example, the SRI CAT 3ID beamline, should give us as much as a 10x gain in flux at the sample with δE=100 meV.

In Fig. 2, we characterize the excitation spectrum in the antiferromagnetic insulating phase in $V_{1.978}Cr_{0.022}O_3$ for Q=2.1Å^{-1} **Q**||**c***.[5] Our energy resolution, which was determined by the full width at half maximum of a Gaussian fit to the elastic line, was δ E = 1.1 eV. At large energy transfer, there are two peaks at an energy-loss of ΔE 9.2 eV and ΔE 13 eV. The higher energy peak has been observed optically at Q ~ 0 Å^{-1},[6] disperses with Q (between 0 Å^{-1} and 4 Å^{-1}), and is narrow so we associate it with a plasmon. The peak at ΔE 9.2 eV is only observed in these finite-Q measurements and only in the antiferromagnetic insulating phase and does not disperse. Thus, we speculate that it is an excitonic feature that is made up of a hole near the top of the O2p band, which has g-like symmetry,[7] and an electron in a V3d band. In order to extract changes in the spectrum brought on by the MIT at smaller energy transfer, we fit the elastic peak in the metallic phase (T_{AFI}>173K) and subtract this from an identical scan in the antiferromagnetic insulator phase at T= 10K. After this subtraction, there is a peak at an energy-loss of ΔE 2.4 eV, seen in Fig. 2. While we do not have the energy resolution in this measurement to study this peak in any detail, we speculate that it arises from electronic excitations associated with the opening up of a Mott-Hubbard gap. We note that an electronic excitation has been observed optically at an energy-loss of ΔE 1.5 eV.[6]

As we have shown here, using inelastic x-ray scattering with 1-eV energy resolution, we can observe interesting charge excitations. Higher energy resolution will allow us to probe even more interesting excitations. However, this comes at the expense of spectrometer throughput. For these measurements in V_2O_3, we had a signal of about 1 cps and a signal-to-noise ratio of 1 with 4x10^{11} photons/sec incident on the sample at 8 keV at NSLS beamline X21. With an energy resolution of 10 meV, which is about Δ = 3.5 kT_c for the superconducting gap in V_3Si, for example, an estimated 10^{10} photons/sec will fall on the sample at 14 keV at the APS SRI CAT 3ID beamline. This should be enough flux to observe low-lying features in the spectrum since the x-ray penetration depth is at least five times deeper at the higher energies. But as we focus on interesting materials with higher-Z elements (higher absorption), such as the high-T_c superconductors, we may need to consider the possibility of using resonant enhancement techniques. Such techniques, which have been extensively developed for elastic magnetic scattering, are currently being developed for application in inelastic x-ray scattering (resonant Raman) at the NSLS.
E. D. Isaacs, AT&T Bell Laboratories

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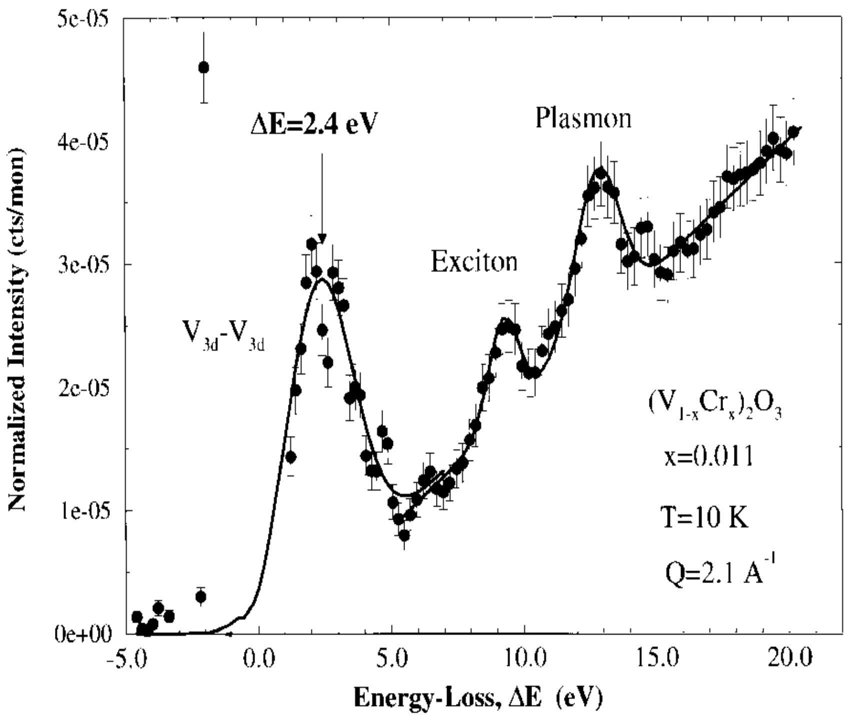

Figure 2. *Charge excitation spectrum in the antiferromagnetic insulating phase of V_2O_3 with momentum transfer $Q = 2k_i sin(q) = 2.1$ Å^{-1}, where $k_i = 2p/l_i$. We speculate that the peak at ΔE = 2.4 eV results from the appearance of a Mott-Hubbard-like gap in the partially filled V3d-band.*

Tales from the Front: Sector 1 Commissioning Activities

Introduction

The past few months have been an exciting time at the APS. Finally, after years of preparation and anticipation, we have synchrotron-produced x-rays and have been able to conduct a few commissioning experiments. So far, the storage-ring current has been rather low and the amount of "user" beam time has been very limited, nonetheless we have made considerable progress toward making the Sector 1 beamlines operational. In this article, descriptions of the Sector 1 first-light and shielding-verification experiments will be given in some detail along with brief reports on several other activities that took place during early beamline commissioning.

First Light

The initial step in commissioning a beamline is a "first-light" experiment, in which the front-end shutters are opened and x-rays are allowed to enter an experimental station for the first time. The actual process of opening the shutters and viewing the beam on a fluorescent screen is simple enough, but a considerable number of hurdles must be cleared prior to the "experiment." Especially in the case of the initial beam at a facility, a number of systems must be brought on-line and integrated for the first time.

By late March 1995, everything seemed to be in place, and we were ready to open the shutters and bring the first bending-magnet radiation into 1-BM-A. The storage ring was operable, though limited to electrons at 4.5 GeV; the 1-BM front end had been installed and aligned; the 1-BM-A station construction had been completed; the equipment and personnel safety systems were active; all necessary temporary shielding had been installed; and a stack of procedures and other documents had been written, reviewed, and approved.

On March 25 at 1:58 a.m., an electron beam was stored for the first time in the storage ring and by 6:03 a.m., we were ready to open the 1-BM shutters. All the required keys had been turned, the cameras were focused, the VCR was recording, and a fair sized crowd was bunched together watching a fluorescent screen on a video monitor. Jon Hawkins (the Experimental Facilities Division (XFD) Personnel Safety System Manager) pushed the button to open the shutters and, lo and behold, nothing happened! A check of the beam-position monitors in the front end and the scintillation detectors inside 1-BM-A confirmed that there was no x-ray beam. This caused considerable consternation, but within a few minutes a consensus opinion was reached that the valve separating the 1-BM front end from the storage ring must be blocking the beam. The suspect valve had to be opened manually, so a storage-ring access was scheduled for later that day, and plans were made to try again the next night.

The next night (March 26), the commissioning team (with many observers) met to try again. The valve had, in fact, been found to be closed and had been subsequently opened, so everyone was optimistic about success. Some difficulties were had in getting stored beam, but, at 7:13 a.m., with 38 μA of stored ring current, Jon once again pressed the shutter-open button, and this time a bright horizontal stripe lit up the fluorescent screen. After a good deal of congratulatory activity, a series of radiation sensitive images (i.e., "burns" in common parlance) were made, and several x-ray beam-position monitor (XBPM) readings were made.

The next available shift for XFD was on April 27, during which the first x-rays from a 7-GeV storage-ring beam were taken into 1-BM-A (at 4:17 a.m., for the record). The improvement in the storage ring performance over the month since the previous beam time was remarkable. As well as operating at 7 GeV, the storage ring had a current of 139 μA with a lifetime of around 7 hours.

On August 9, we were ready to open the 1-ID shutters and receive insertion-device (ID) x-rays for the first time. An APS undulator A had been installed during the preceding down period, and the accelerator studies had shown that the storage ring had performed very well with the undulator installed. The minimum gap of the undulator was limited to 15.8 mm by the commissioning chamber that had been installed for initial ID operations. (The "mature" phase chamber has a minimum gap of 10.5 mm. This chamber was installed in the 1-ID straight section in September.) Because the cooling for the chamber was not fully implemented, the storage-ring current was limited to less than 1 mA whenever the undulator was not at fully opened gap (200 mm). (Stored currents of a few mA were regularly available for open-gap operations.)

At 6:00 p.m., with the undulator gap fully open, the 1-ID front-end shutters were opened. The bending-magnet radiation from the dipoles on both ends of the straight section was clearly seen on a fluorescent screen. At 10:05 p.m., with a current of 0.5 mA, we began closing the undulator gap from 200 mm towards 15.8 mm. From the fully open position, the undulator takes a few minutes to close, so considerable anticipation was generated while waiting for the undulator beam to show up on the fluorescent screen. At a gap of approximately 50 mm, the undulator beam became clearly visible. By 30 mm, the image was very bright, and, at 20 mm, the fluorescent screen was utterly destroyed. We replaced the ruined screen with a copper plate coated with fluorescent material and closed the gap to 15.8 mm without further incident. An image of this beam is shown in Fig. 1. (Note that the radiation sensitive paper has a very nonlinear response and is therefore a little misleading. The undulator beam is orders of magnitude more intense than the bending-magnet beam.)

Shielding Verification

One of the first things we wanted to do during the initial beam time was to verify the shielding for the 1-BM and 1-ID white-beam stations. As well as the obvious safety considerations, we were anxious to find out if the APS shielding guidelines were sufficient.

The photon beam produced by the storage ring has two components, synchrotron radiation and bremsstrahlung, which require separate shielding strategies. The characteristics of synchrotron radiation are well known to readers of this newsletter and do not need to be described, but it should be noted that the relatively high storage-ring energy of the APS (7 GeV) leads to much higher critical energies than at most other synchrotron facilities. For bending-magnet radiation, the APS has a critical energy of 19.5 keV, compared to 5.1 keV, 4.7 keV, and 11.5 keV for NSLS, SSRL, and CHESS, respectively. A comparison of insertion-device sources is more complicated but follows similar trends. The practical consequence of high critical energies is that there will be a considerable amount of synchrotron radiation above 100 keV. In the few hundred keV range, lead becomes considerably less efficient as a shielding material, and lighter materials (e.g., steel, aluminum) have essentially no stopping power.

Fig. 1 First undulator beam at the APS.

During ordinary operations (i.e., not during an injection or beam loss), bremsstrahlung is produced by the scattering of the electron (or positron) beam from the residual gas in the storage-ring vacuum. The scattered beam is forward-directed into a cone roughly 73 μrad ($1/\gamma$) wide. Its intensity is proportional to the storage-ring vacuum and to the length of storage-ring beam path seen by the beamline. The bremsstrahlung spectrum has approximately a 1/E dependence (where E is the energy of the bremsstrahlung photon), with the maximum energy being equal to the storage-ring energy (i.e., 7 GeV). As with synchrotron radiation, the relatively high storage-ring energy of the APS leads to an increased amount of bremsstrahlung when compared to most existing facilities. Bremsstrahlung production is proportional to the storage-ring energy to approximately the third power.

Bremsstrahlung shielding calculations are considerably more complicated than those for synchrotron radiation. When a bremsstrahlung beam strikes a solid piece of material, an electromagnetic shower is created which includes electrons, positrons, and neutrons, as well as photons. Whereas a couple centimeters of lead will pretty much stop synchrotron radiation, for the bremsstrahlung this amount of material will lead to a fully developed shower where the potential radiation dose is the highest. P. K. Job (XFD's Radiation Physicist) has carried out a number of studies using Monte-Carlo simulations of electromagnetic showers to help us better understand bremsstrahlung scattering. One of the objectives of the shielding verification studies was to compare his calculations to measured values.

In an APS ID white-beam station, the direct radiation (both synchrotron and bremsstrahlung) is stopped by a thick block of tungsten (20 cm along the beam) that is protected from melting by a water-cooled piece of copper. Practically no radiation makes it through the stop, but considerable scattered radiation is generated inside the experimental enclosures whenever the photon beam strikes any beamline component (e.g., a slit or monochromator).

Scattered synchrotron radiation is approximately isotropic, with most of the photons of concern for shielding having energies between 200 keV and 400 keV. On the other hand, scattered bremsstrahlung is strongly forward-directed, and for relatively thick targets, tends to peak in the few MeV range. Consequently, the shielding for the two types of scattering must be different and the verification tests should reflect this difference.

For the verification tests, targets to simulate worst-case situations were designed by P. K. using various computer codes. For synchrotron radiation, blocks of aluminum one cubic centimeter in size were placed at distributed positions along the beam path. For bremsstrahlung, the worst-case target was determined to be a slab of tungsten 2-cm thick placed as far upstream in the station as possible. During shielding verification experiments, the targets are installed and aligned by XFD personnel, and the radiation measurements are made by ANL Health Physics.

The shielding tests of 1-BM-A and 1-BM-B were made on June 28 and 29 with a storage-ring current typically around 3.5 mA. The tests were rather uneventful, with no significant leaks being found. The only detectable readings above background were from very sensitive detectors placed in contact with door/floor interfaces. Based upon the data, the stations were certified to operate up to currents of 25 mA. (When a 25 mA beam is available additional tests will be made.)

The 1-ID-A and 1-ID-B shielding tests were made on August 9 and 11. The synchrotron radiation was measured with the minimum available undulator gap (15.8 mm) and a storage-ring current of between 0.5 and 1.0 mA. The bremsstrahlung was measured with a current of 4 mA and a storage-ring vacuum of approximately 2×10^{-7} Torr. For what is likely to be the only time in the history of the APS, the poor vacuum proved advantageous. Storage-ring vacuum levels are expected to improve to about 10^{-9} Torr during mature operations, so the bremsstrahlung measurements made at 2×10^{-7} Torr scale to a storage-ring current of more than 200 mA!

The APS shielding recommendation for the downstream walls of ID white-beam stations is 50 mm of lead with an additional 50 mm of lead for a square meter transversely centered about the direct beam. The stations are constructed with 50 mm of lead in the downstream wall panels with the intent to use lead bricks as required to give the additional shielding. On 1-ID-A and 1-ID-B, the additional shielding was intentionally not added so that measurements could be made to compare to P. K.'s calculations. His calculations predict that a dose rate of 0.48

mrad/hr should be measured at the back of 1-ID-B for the conditions given above. The highest measured value was found to be 0.26 mrad/hr. Given the uncertainty in several experimental factors, this is satisfactory agreement. It should also be noted that no measurable dose from neutrons was found.

For the synchrotron radiation, no significant levels were found with the exception of a minor leak at a weak spot at the 1-ID-A ratchet wall/station roof interface. The leak was due to a manufacturing oversight that is being fixed by the vendor. (This area will be tested again during the next available beam time.) Based on this information, 1-ID-A and 1-ID-B were certified up to 5-mA, 15.8-mm minimum gap operations.

1-BM Monochromator

While the first beam and shielding verification experiments were being carried out on 1-ID, a flurry of activity was taking place on 1-BM. A temporary monochromator (known as the "box" around XFD) was installed in 1-BM-A. Within a couple of days, it was up and running. A scan of the Ni absorption edge from this monochromator is shown in Figure 2.

Direct Bremsstrahlung

A considerable effort is being made at the APS to approach the various aspects of radiation safety from a scientific standpoint. An example of this approach is the analysis involving selection of the targets for the shielding verification tests (as described above). Another example is a collaboration, headed by P. K. Job, between XFD and ANL High Energy Physics to directly measure the gas bremsstrahlung spectrum from the APS storage ring. This measurement will be made using a calorimeter consisting of 25 lead glass blocks (each 6.3 cm x 6.3 cm x 40.0 cm) with corresponding phototubes.

As an initial step in this experiment, one lead glass block was placed in the 1-ID bremsstrahlung beam, and a series of calibration measurements were made. This was done while the synchrotron-radiation shielding test was being carried out on 1-ID. (The aluminum block used to scatter the synchrotron radiation has practically no effect on the bremsstrahlung beam.) An example of the data that were collected is shown in Figure 3.

X-ray Beam-Position Monitor

Throughout the shielding verification measurements, Deming Shu was parasitically conducting a series of tests on the front-end x-ray beam-position monitors (XBPM). The XBPMs measure photoelectrons generated by pairs of metallized diamond blades placed at the edges of the x-ray beam. Comparison of the relative currents in the two blades can be used to deduce the beam position between the blades. One concern about XBPM performance is how well the undulator radiation can be discriminated from the residual bending-magnet radiation. The data from Deming's tests show that, for the noisiest blade of the upstream XBPM, the undulator signal (at 15.8-mm gap) is

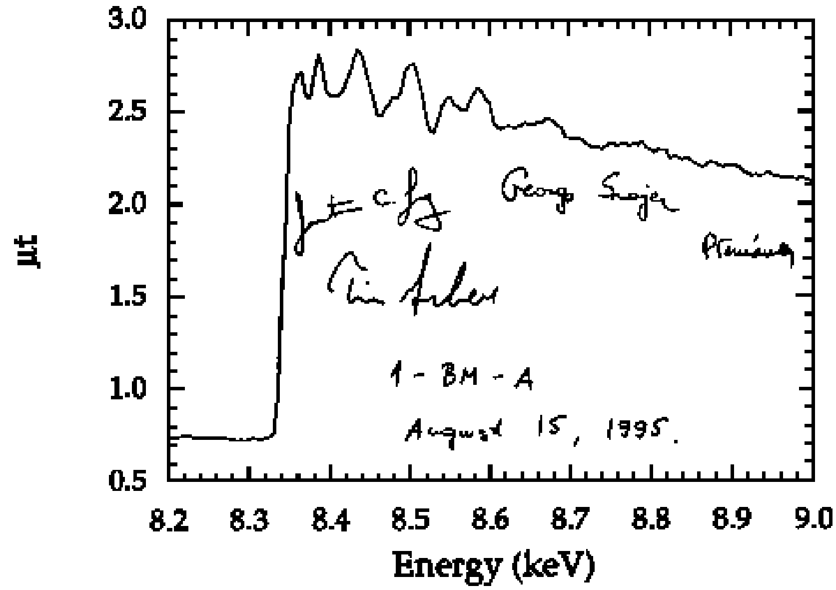

Figure 2. An energy scan of a nickel foil using the 1-BM temporary monochromator.

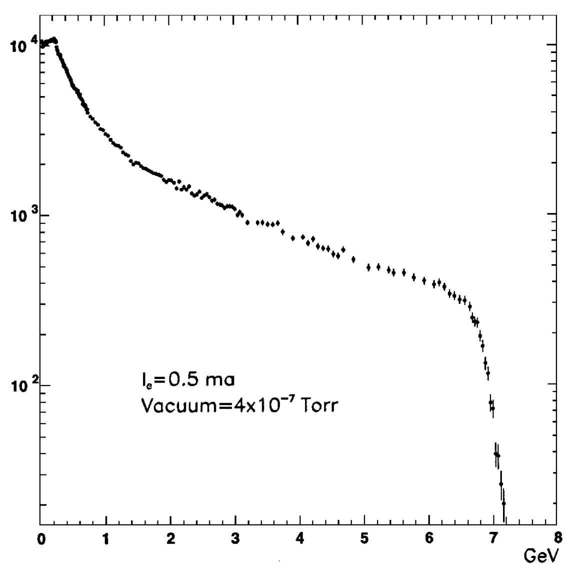

Figure 3. Gas bremsstrahlung spectrum measured with a lead glass scintillator.

about a factor of 10 higher than the bending-magnet background. (The downstream XBPM showed even better performance.)

Deming also carried out an experiment in 1-ID-A on a newly designed window/XBPM combination (known as the TBPM, for transmission beam position monitor). In this design, a 160-μm thick CVD diamond is coated with 2 μm of aluminum separated into four quadrants. As the x-ray beam is transmitted though the diamond, the current measurements from the quadrants are used to determine the beam position. This TBPM performed very well, with the undulator beam giving a signal that was a factor of 100 greater than the residual bending-magnet radiation. A calibration curve from the TBPM is shown in Figure 4.

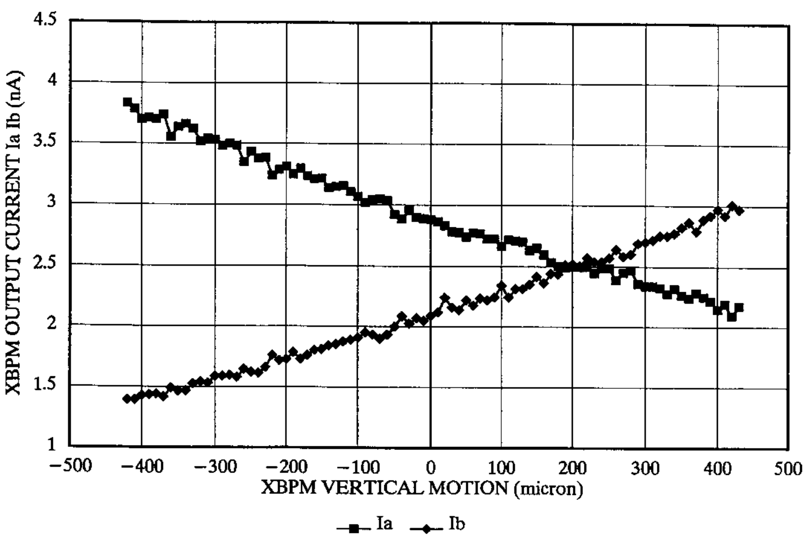

Figure 4. Calibration measurements from the transmission beam-position monitor.

Kohzu Monochromator

Toward the end of the August run, the Kohzu double-crystal monochromator was installed in 1-ID-A. About 6 hours of beam time were available for monochromator tests. In this short period time, we were able to conduct several tests that yielded encouraging, though certainly preliminary, results. A monochromatic beam was brought through the double-crystal setup within a minute of getting the initial beam, and the alignment proved good enough to track from 6 keV to 18 keV without losing the beam. During these long energy scans (essentially from the first to the third harmonic of the undulator at a 15.8-mm gap), we were able to watch the monochromatic beam on a fluorescent screen. The change of the shape of the beam as a function of energy is quite dramatic. Two of the monochromatic beam images are shown in Figures 5a and 5b.

Credits

The following is a list of participants in the activities discussed above. All are from XFD unless otherwise noted. The first light experiments were carried out by Dennis Mills, Dean Haeffner, Patric Den Hartog, Mark Keeffe, Bill McHargue, Liz Moog, Mohan Ramanathan, Deming Shu, and George Srajer. The shielding verification studies were made by Dean Haeffner, P. K. Job, Mark Keeffe, Bill McHargue, Mohan Ramanathan, George Srajer, and ANL Health Physics. The 1-BM monochromator installation and testing were done by George Srajer, Steve Brauer, Patricia Fernandez, Tim Graber, Mark Keeffe, Jonathan Lang, and Bill McHargue. The 1-ID Kohzu monochromator tests were made by Wah Keat Lee, Dennis Mills, Dean Haeffner, and Mark Keeffe. The 1-ID calorimetry experiment was carried out by P. K. Job, Bob Stanek (ANL/HEP), and Mark Keeffe. The BPM studies were made by Deming Shu, Juan Barraza, Tunch Kuzay, and Mohan Ramanathan.

Also, thanks are given to the APS Floor Coordinators (Rod Salazar, Frank Bellinger, Bob Ferry, and Tim Smith) who were involved in all the above activities, to Tim Mooney for his help with EPICS data acquisition, and to the accelerator physicists for all of their cooperation. *Dean Haeffner*

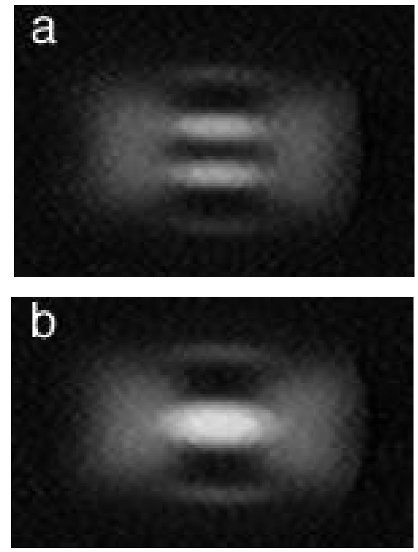

Figure 5a and b. Image of the 1-ID Undulator A beam (gap of 15.8 mm) downstream of the Kohzu double-crystal monochromator. a) 17 keV, b) 18.3 keV.

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Address additions, changes and deletions are welcome. Forward them to the SRI CAT Secretary.

Next Issue - January 1996

Calendar

Oct. 29-Nov. 1, 1995 International Workshop on Scattering Experiments with High Energy Synchrotron Radiation, Schwerin, Germany.

Who's New

Michael Hoffberg - Scientific Research Associate

Michael Hoffberg has joined the SRI CAT as a member of the X-ray Optics Group. He has a B. S. in EE from Yale and a M. S. degree from Illinois Institute of Technology. Mike will be working with Brian Rodricks on detector development

Chuande Liu - Scientific Research Associate

Chuande Liu has joined the SRI CAT as a member of the X-ray Optics Group. He comes to us with five years software experience at U. S. Robotics. He has a M. S. in computer science and is a Ph. D. candidate at Illinois Institute of Technology. Chuande will be working with Brian Rodricks on detector development.

Publications

Alp, E. E., W. Sturhahn, T. Toellner, "Synchrotron Mossbauer Spectroscopy of Powder Samples", NIM B Beam Interactions with Materials and Atoms, *Nucl. Inst. & Meth. in Phys. Res. B* **97** (1995) 526-529

Sturhahn, W., T. S. Toellner, E. E. Alp, X. Zhang, M. Ando, Y. Yoda, S. Kikuta, M. Seto, C. W. Kimball, and B. Dabrowski, "Phonon Density of States Measured by Inelastic Nuclear Resonant Scattering", *Phys. Rev. Lett.* **74** (1995) 3832-3835

Yahnke, C. J., G. Srajer, D. R. Haeffner, D. M. Mills, and L. Assoufid, "Magnetic Compton Scattering Studies of the Invar Effect in Fe_3Pt", *Mat. Res. Symp. Proc.* **375** (1995) 221-227

Safety Notes

Crate and Steel Banding Hazards

The continuing shipments of crated equipment and palletized materials secured with steel and plastic bands expose personnel to a number of hazards.

Unpack items with care:

- Use the right tool for the task.
- Wear proper protective equipment, including leather gloves and eye protection (possibly a face shield should be used), and shoes that provide toe and ankle protection and protect against sole penetration.
- Properly dispose of the packaging material immediately.

Nails and staples left protruding from crates and associated debris can cause serious injury. Remove nails and staples (or bend them down) so that they cannot cause punctures, cuts, or scratches.

Banding, particularly metal strap, can "spring" and cause cuts and eye injuries. After removal, place the banding in a box so that it cannot be stepped on and cause an injury to you or others.

If you have any questions, contact Bill Wesolowski (2-0169, Rm. 431 D002) or Bruce Stockmeier (2-9394).